Increasing Energy Efficiency in Institutional Food Service Facilities

By: Thomas D. Van Liew, P.E., G.B.E., C.E.M.
State of Hawaii – DBEDT/SID

Presentation Overview

- Institutional Food Service Facilities – General.
- Energy Consumption, EUI's and CUIs.
- Energy conservation measures (ECMs) applicable to Food Service Facilities.
- Water Consumption and RCM opportunities in Food Service Facilities.
- Ideas on How to Design a "Green" Food Service Facility.
- Hickam AFB Study of Six Food Service Facilities.
- Results of Energy Audits and ECMs.
- Improvements for Future Food Service Audits.

Why Are Food Service Facilities BIG Consumers?

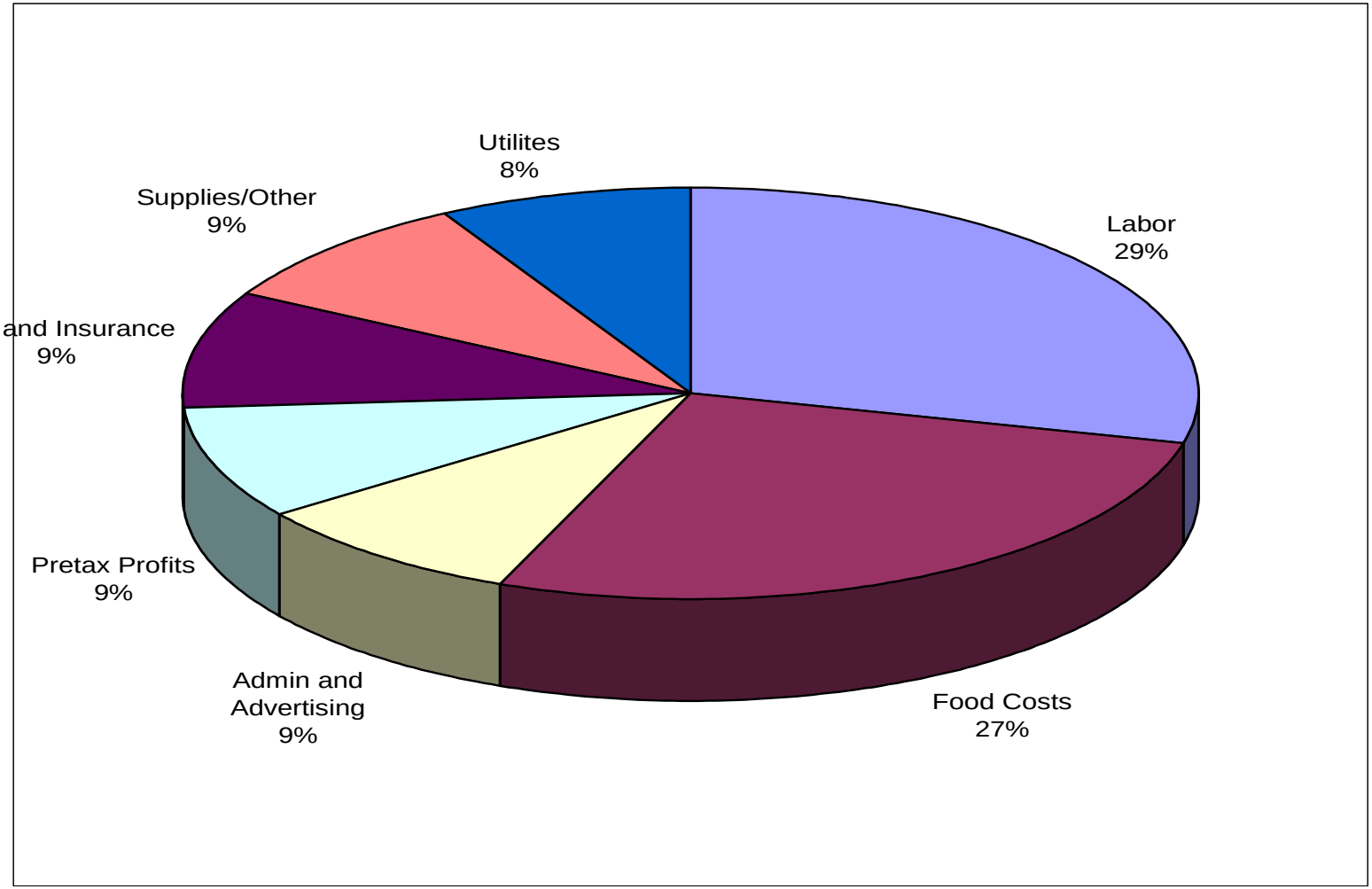
- Long operating hours,
- High Occupancy Level (people load),
- Equipment (HVAC, lighting, cooking, refrigeration, slicers, dicers, Etc.),
- Multiple Fuel Sources (electric, fuel oil, propane, natural gas),
- Operating Space (small square footage),
- High Ventilation Requirements.

Types of Food Service Facilities

- Fast Food - Limited Menu (Taco Bell)
- Fast Food - Extensive Menu (Jack in Box)
- Restaurant - Coffee Shop (Not open evenings)
- Restaurant – Cafeteria (School facility)
- Restaurant – Pizza House (Round Table)
- Restaurant – Dinner House – Ltd Menu (Specially)
- Restaurant – Dinner House – Full Menu (Denny's)

The type of food service facility can have a BIG impact on energy and water consumption as well as other resources (sewage, disposables, etc.)

Typical Food Service Facility Operating Expenses



Defining Energy Efficiency Energy Benchmarks

The **Energy Usage Index (EUI)** is a method of benchmarking similar facilities to determine relative building efficiency and potential for energy conservation.

EUI = kWh/sq.ft-year (electric only) 0r kBtus/sq.ft-year (multiple fuel sources).

The **Cost Utilization Index (CUI)** is a measurement of the relative cost per square foot ($/sq.ft-year). The higher the CUI, the more expensive it is to operate.

The End Use Index (EUI) and Cost Utilization Index (CUI) varies with many factors. Some of these factors include:

Age of building, operating hours, type of food service facility, meals per day, Weather,

Efficiency of energy consuming equipment (HVAC, lighting, refrigeration, cooking, etc.),

Management and employee strategies and awareness in energy conservation.

Restaurant Energy Usage

Typical End-Use Loads for Food Service Facilities in Hawaii.

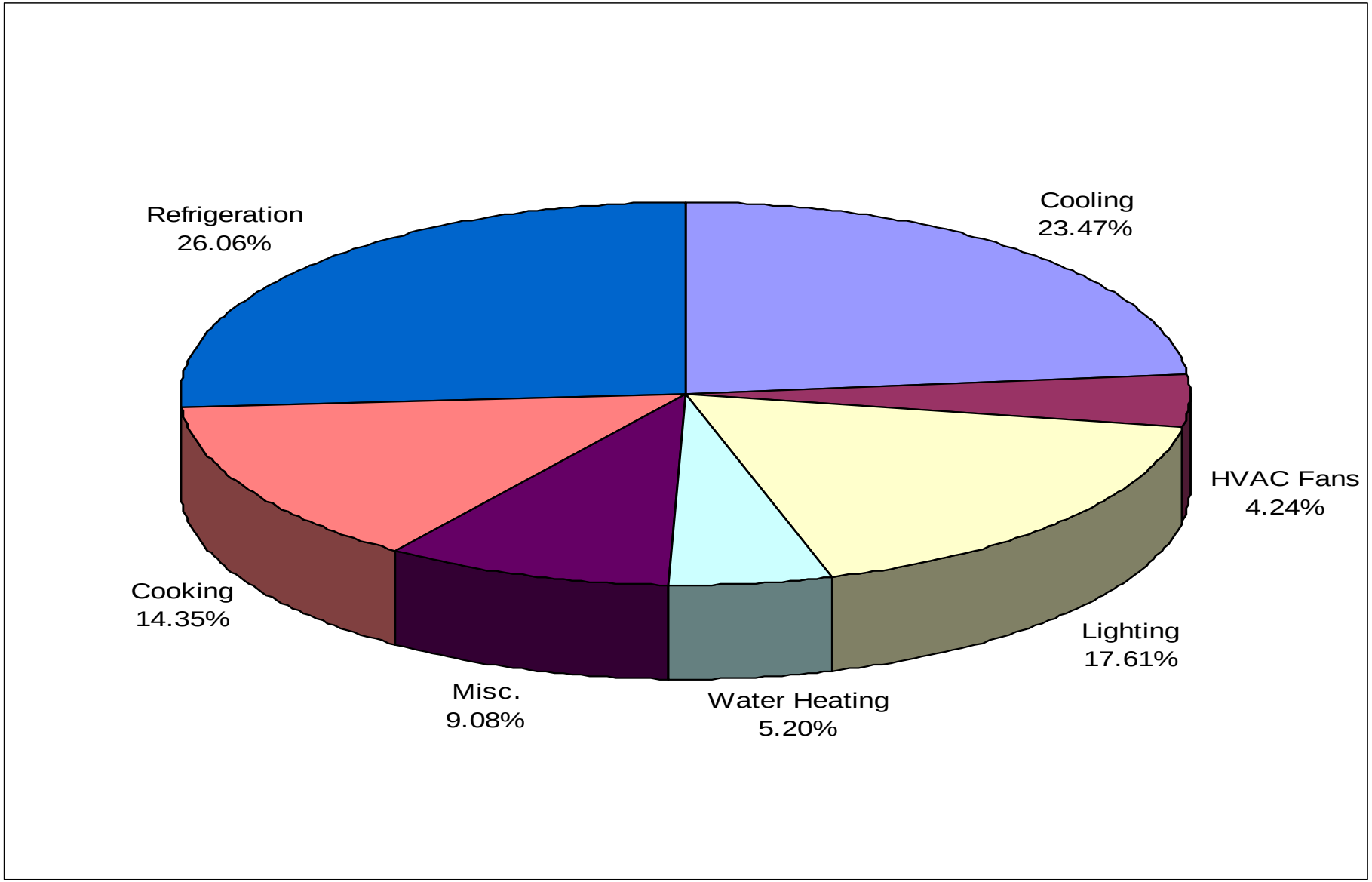
Average:
EUI = 52 kWh/sq.ft-year
CUI = $8.84/sq.ft-year
(HECO market (electric only).

Fast Food = 72.6 kWh/sq.ft-year

Full Service = 51.6 kWh/sq.ft-year

Pizza shop = 35 kWh/sq.ft-year

Restaurant End-Use Loads



Energy Conservation Measures – Page 1

- **List of Energy Conservation Measures (ECMs) for Food Service Industries**
  - **“Hawaii Climate”**

- **Building envelope**
  - Evaluate added insulation levels if applicable.
  - Evaluate infiltration controls.
  - Reduce solar heat gain through window films.
  - Keep doors and windows closed during A/C operation.

- **HVAC**
  - Reduce A/C operational times as possible.
  - Reduce run times on fan coils units where possible.
  - Replace existing window air conditioners with new more efficient units
  - Replace split/DX systems with new more effect systems.
  - Replace air cooled chillers with more effect chiller systems.
  - Downsize A/C systems to meet loads where applicable.
  - Install desuperheaters or heat recovery systems to improve A/C performance.
  - Reduce ventilation rates of HVAC/cooking hoods if possible.
  - Install variable flow hoods to reduce outside air for ventilation.

Energy Conservation Measures – Page 2

- **Lighting**
  - Reduce operating hours
  - Replace T12 lamps utilizing magnetic ballasts with T8s and electronic ballasts.
  - Replace incandescent with fluorescent or cold cathode lamps.
  - Install photo cells and time clocks for outside lighting and parking lots.

- **Domestic Hot Water**
  - Reduce hot water set point temperatures were possible.
  - Insulate pipe and fixtures where needed.
  - Consider chemical sanitization systems.
  - Utilize heat recovery for preheating water.
  - Utilize solar water heating systems.
  - Utilize water heating heat pumps (E-Tech).
  - Increase efficiency of water heating systems.

- **Motors**
  - Reduce motor run times where possible.
  - Install premium efficient motors.
  - Install variable frequency drives on motors exceeding 3-5 HP where possible.

Energy Conservation Measures – Page 3

- **Refrigeration**
  - Replace older refrigeration and ice machines with more effect systems.
  - Increase refrigeration temperature set points as feasible.
  - Provide regular maintenance to keep evaporator and condenser coils clean of debris.
  - Install plastic strip curtains or air curtains on walk in coolers and freezers.
  - Install Energy Star equipment.

- **Cooking Equipment**
  - Replace less efficient cooking equipment with more efficient systems
  - Reduce operating times as feasible.
  - Turn off cooking equipment when not in use.
  - Covert gas to electric (or visa versus) where possible.
  - Provide regular maintenance.

  - **Other**

Additional Resource Conservation Measures

Reduce Water Consumption.

Repair water leaks.

Turn off water when not in use.

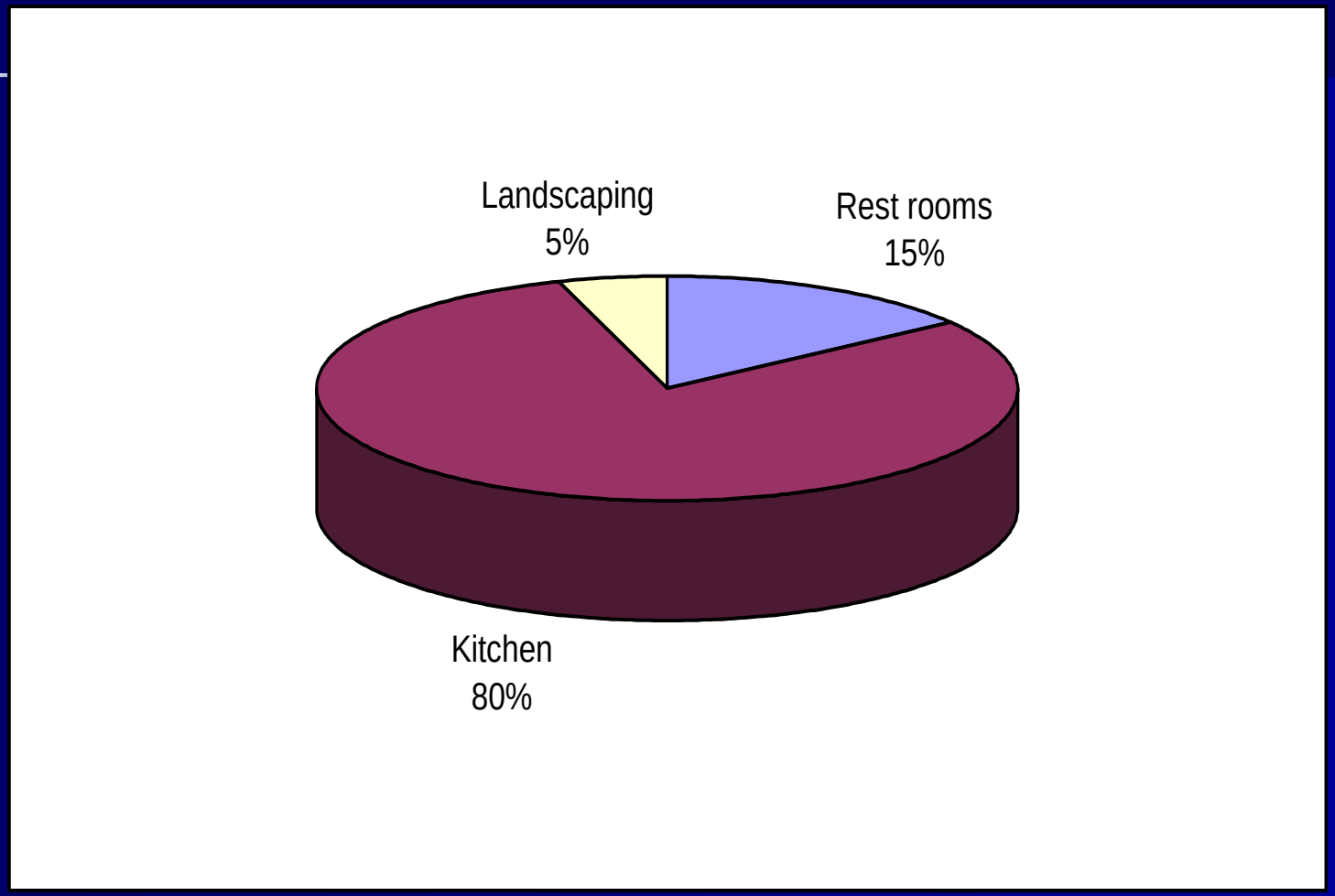
Low flow urinals. And toilets.

Utilize full dishwasher cycles.

Energy and water efficient ice makers and water consuming equipment.

Encourage recycling of paper goods, metals, glass, and plastic.

How Water Is Consumed in a Food Service Facility



How to Design a "Green" Food Service Facility?

Green Food Service Facilities

- **Building orientated to utilize sun, wind and shade while meeting or exceeding Hawaii Model code requirements using daylighting functions where possible.**
- **Premium energy efficient A/C with packaged desuperheaters with EMS or time clock system to shut system down at night.**
- **Energy efficient cooking hoods.**
- **Reduce outside air during unoccupied periods.**
- **Premium efficient motors on air handling units (AHUs), 3HP and above.**

Green Food Service Facilities – Page 2

- Energy Star refrigeration and cooking equipment.
- Reduced water consumption and waste water rejection.
- Recycling center for plastic, aluminum and other resources.
- Utilize or properly dispose of grease and other wastes.
- Water efficient landscaping system.

HICKAM AFB, HONOLULU, HI.

ENERGY ASSESSMENTS OF SIX FOOD SERVICE FACILITIES.

- Sponsored by: Federal energy Management Program (FEMP) and the Department of Energy (DOE)

Contractor: Technology & Management Services (TMS)

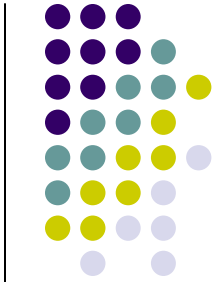
HICKAM AFB – BACKGROUND INFORMATION

Hickam AFB Food Service Facilities (Analyzed).

Number of Buildings	6
Square feet:	46,000
Electric consumption:	2.3 million kWh/year
	$345,000/year
	52,516 gallons propane
	$155,128 gallons propane
	$500,000 per year

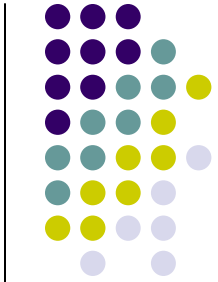
Average EUI: 308 kBtus/sq.ft-year.

The Facilities



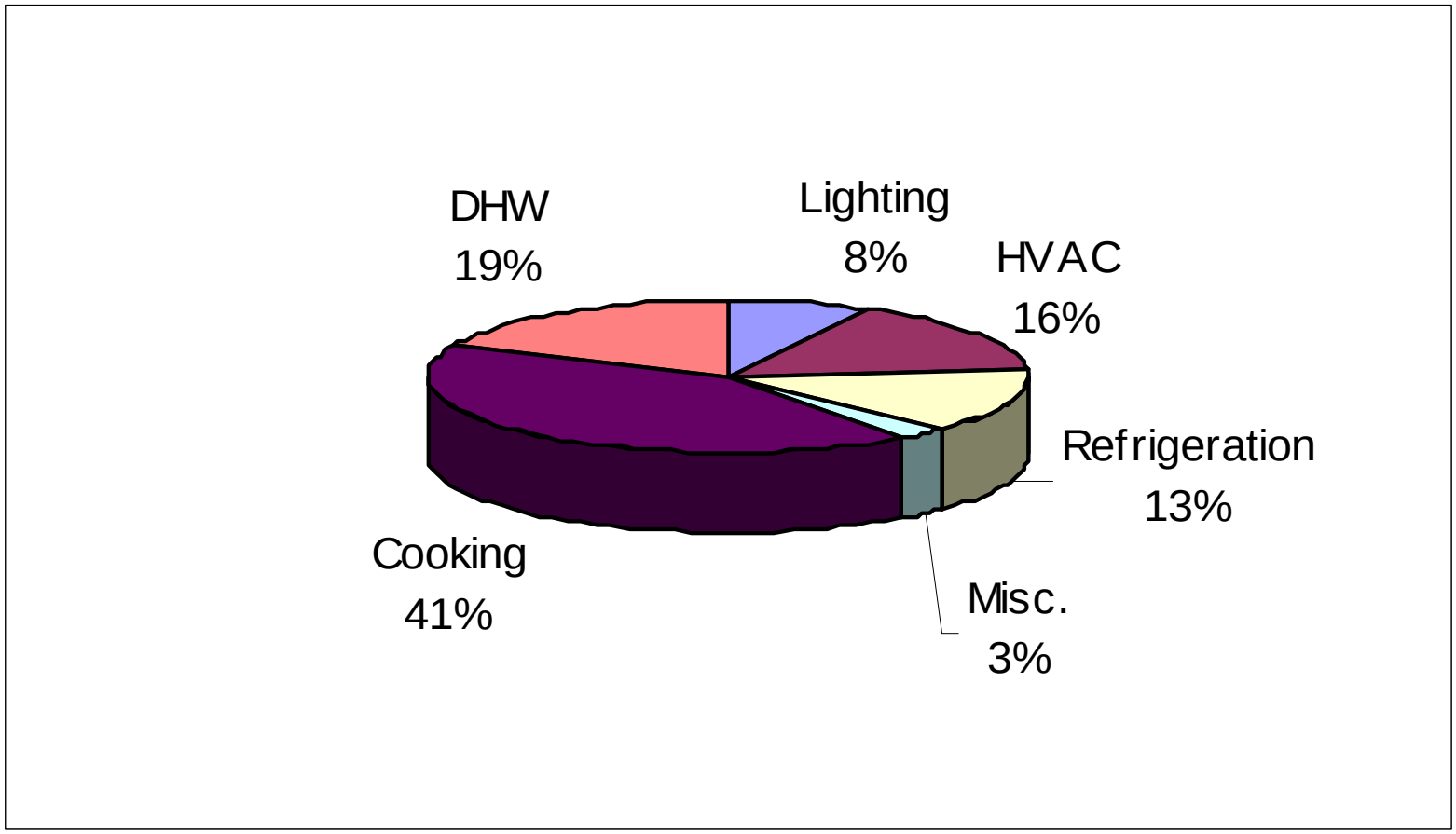
- Orville and Wright – Breakfast and Lunch
- Sea Breeze Restaurant – Ocean View
- Par 3 Golf Course – L & L Restaurant
- Main Golf Course – Dinning Area
- Offices Operations (Conference rooms and Lounge)
- Hale Aina Restaurant (Main Chow Hall)

Food Service Facilities at Hickam

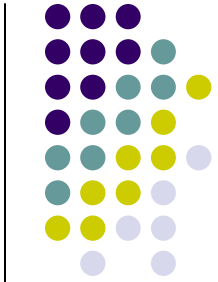


Food Svc Number	Area (Sq. Ft)	Electric Usage (kWh/year)	Electric Usage ($year)	EUI (kWh/sq-ft-yr)	Gas Usage Gals/year	Gas Usage ($/year)	EUI Gas (kBtus/sq.ft-yr)	Total Costs ($/year)	TOTAL EUI (kBtus/sq.ft-yr)	TOTAL CUI ($/sq.ft.-yr)
BLD 1	7,593	303,720	$45,558	40.0	14,494	$33,554	174.3	$79,112	310.8	$10.42
BLD 2	13,746	977,074	$146,561	71.1	12,843	$29,732	85.3	$176,293	327.9	$12.83
BLD 3	3,434	137,360	$20,604	40.0	8,889	$20,578	236.3	$41,182	372.9	$11.99
BLD 4	3,654	146,160	$21,924	40.0	7,849	$18,170	196.1	$40,094	332.6	$10.97
BLD 5	14,622	584,880	$87,732	40.0	18,249	$42,246	113.9	$129,978	250.5	$8.89
BLD 6	3,720	148,800	$22,320	40.0	4,686	$10,848	115.0	$33,168	251.5	$8.92
Totals	46,769	2,297,994	$344,699	n/a	52,516	$155,128	n/A	$499,827	307.7	$10.67
										$499,827

Food Service Facilities at Hickam
End-Use Pie Chart



ECMS ANALYZED



Building Envelope – solar reflective film

HVAC – High efficiency A/Cs and chillers

Lighting – T12s to T8s and electronic Ballasts

Motors – Premium efficiency motors

DHW – Solar water heating & desuperheaters

Refrigeration – Strip curtains for freezers

Miscellaneous – Tiki Torches

HVAC ECM SUMMARY SHEET

Bldg	Unit	Date of Manuf	A/C Tons	EER	kW/ton	Load Factor	Operating hours (hrs/yr)	kWh per year (kWh/yr)	Annual Cost	Savings Per Year	Equip Cost - Means ($)	Contingency	Hawaii Cost adjustment	Pay back (yrs)
900	Carrier package	1997	10	8.5	1.41	0.75	5500	58,235	$8,735					
	Potential Replacement		10	10.8	1.11	0.75	5500	45,833	$6,875	$1,860	$8,798	$9,677	$12,580	6.8
907	Chiller	Aug-99	45	7.1	1.20	0.75	5500	222,750	$33,413					
	Potential replacement*		45	9.6	1.00	0.75	5500	185,625	$27,844	$16,959	$63,161	$69,477	$90,320	5.3
3465	Carrier Split DX	Mar-96	20	8.5	1.41	0.75	5000	105,882	$15,882					
	Potential replacement		20	10.8	1.11	0.75	5000	83,333	$12,500	$3,382	$19,090	$20,999	$27,299	8.1
3572	Carrier Split DX	Aug-99	10	8.5	1.41	0.75	5000	52,941	$7,941					
	Potential replacement		10	11	1.09	0.75	5000	40,909	$6,136	$1,805	$8,798	$9,677	$12,580	7.0
2105	Trane Split DX	Sep-98	20	8.5	1.41	0.75	5000	105,882	$15,882					
	Potential replacement		20	10.8	1.11	0.75	5000	83,333	$12,500	$3,382	$19,090	$20,999	$27,299	8.1
1860	Chiller	Aug-99	60	6.7	1.20	0.75	6000	324,000	$48,600					
	Potential replacement*		60	9.7	1.00	0.75	6000	270,000	$40,500	$26,696	$85,218	$93,740	$121,862	4.6

P.E. MOTOR ECM SUMMARY SHEET

Bldg	Load	No.	HP	N	LF	Operating hours/year	kWh per year	Annual Energy Cost	Savings Per Year	Replacement Cost Means ($)	Contingency	Hawaii Cost adjustment	Pay Back (yrs)
900	AHU	1	2	84	0.85	5500	8,304	$1,246					
	Replacement	1	2	86.5	0.85	5500	8,064	$1,210	$36	$607	$668	$868	24.1
907	5 AHUs	1	5	84	0.85	5500	20,759	$3,114					
	Replacement	1	5	89.5	0.85	5500	19,484	$2,923	$191	$729	$802	$1,042	5.4
		2	2	84	0.85	5500	16,607	$2,491					
	Replacement	2	2	86.5	0.85	5500	16,127	$2,419	$72	$1,214	$1,335	$1,736	24.1
		1	2	84	0.85	5500	8,304	$1,246					
	Replacement	1	2	86.5	0.85	5500	8,064	$1,210	$36	$607	$668	$868	24.1
		1	5	84	0.85	5500	20,759	$3,114					
	Replacement	1	5	89.5	0.85	5500	19,484	$2,923	$191	$729	$802	$1,042	5.4
	CHWP Motors	2	5	86.5	0.85	5500	40,318	$6,048					
	Replacement	2	5	89.5	0.85	5500	38,967	$5,845	$203	$729	$802	$1,042	5.1
1860	AHU	1	7.5	87.5	0.85	6000	32,611	$4,892					
	Replacement	1	7.5	91.7	0.85	6000	31,117	$4,668	$224	$1,020	$1,122	$1,459	6.5
	CHWP Motors	2	5	86.5	0.85	6000	43,984	$6,598					
	Replacement	2	5	89.5	0.85	6000	42,509	$6,376	$221	$729	$802	$1,042	4.7
3465	AHU	1	3	84	0.85	5000	11,323	$1,698					
	Replacement	1	3	89.5	0.85	5000	10,627	$1,594	$104	$626	$689	$895	8.6
3572	AHU	1	2	84	0.85	5000	7,549	$1,132					
	Replacement	1	2	86.5	0.85	5000	7,331	$1,100	$33	$607	$668	$868	26.5
							25,824,997	$3,873,750					

WATER HEATER – DESUPERHEATER ECM
Cost Estimate

"Desuperheaters in Hawaii are the best thing since sliced cheese"

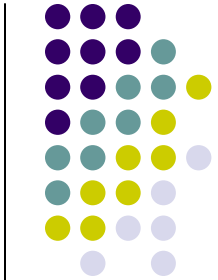
Building 1860

Description	Quantity	Units	Materials		Labor		Total
			Unit Price	Amount	Unit Price	Amount	
Doucet Desuperheater	1	60 ton	$8,572.00	$8,572	$5,725.00	$5,725	$14,297
Water storage tank	1		$2,450.00	$2,450	$54.50	$55	$2,505
Circulating Pump	1			$355	$98	$98	$453
Piping	120	linear feet	$3.02	$362	$5.75	$690	$1,052
				$0		$0	$0
				$0		$0	$0
Subtotal Cost							$18,307
Contractor's O&P						20%	$3,661
Contingency						10%	$1,831
Engineering & Design						0%	$0
Cost Index Adjustment, Honolulu						30%	$5,492
Total Incremental Cost							**$29,291**

Hickam AFB Food Services Project - Total Of ECMs

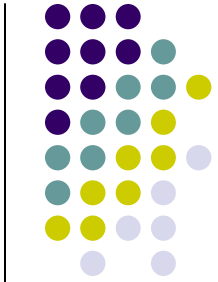
Food Svc Number	BLD NO.	Energy Savings (MMBtus/yr)	Energy Savings ($year)	Total Costs ($)	Simple Payback (years)
Solar Water Heating	3,465	295	$7,488	$60,245	8.0
Heat Pump Water Heaters	900 & 3572	277	$7,398	$36,544	4.9
HVAC Operational Changes	900 & 1860	441	$19,395	$5,044	3.9
High Efficiency A/C	All	548	$54,084	$291,940	5.4
PE Motors	All	26	$1,135	$6,524	5.7
Window Film	900 & 1860	12	$537	$3,937	7.3
Lighting	1,860	43	$1,882	$19,398	10.3
Air curtains	3,720	535	$24,647	$15,159	0.7
Tiki Torches	907	12	$294	$358	0.9
Totals	n/a	2,189	$116,860	$439,149	3.8

Summary- Food Service Facilities



- They are energy intensive facilities which utilize multiple fuel sources and many types of equipment.
- They have long operating hours and high occupancy levels so they provide great potential for energy and resource conservation.
- The most common and cost effective ECMs are: window tinting, premium efficient A/C, lighting, heat pump water heaters, solar water heating, desuperheaters, PE motors, Energy Star refrigeration and cooking equipment and air curtains on walk in freezers.

Summary (continued)



- Paybacks will vary with operating hours and the “base” and “enhanced” cases.
- For the Hickam Project, ECM potential savings was 23%, a payback of less than 5 years or ROI greater than 20%.
- Implement those measures which are most cost effective or have the highest impact on consumption.
- An effective operation and maintenance (O&M) program and good “top down” Energy Management Program can result in energy savings between 5-20% with little or no major investments.
- If it’s a **new building**, apply these sample principals and make it a “Green” Food Service Facility.

Improvements for future food Service Facilities Audits

* Get accurate electric, gas and other fuel source information.
* Get water and sewer consumption data.
* Monitor total, HVAC and refrigeration equipment loads.
* Evaluate cooking equipment loads and ECMs.
* Provide training on energy conservation to management and staff.